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(54) **Coated abrasives for abrasive tools**

(57) An abrasive composition consisting of abrasive particles such as cubic boron nitride or diamond and a coating thereon wherein the coating may be a multilayer composite coating of either (1) four layers if the first metal layer is chemically bonded to the surface of the abrasive particles or (2) three layers if the first metal layer is physically adhered to the surface of the abrasive particles, or the coating may be a single co-deposited metal

layer of cobalt-nickel-phosphorous. The four layers may be, for example, titanium, nickel-phosphorous, nickel and nickel-phosphorous. The three multilayer composite layers may be, for example, nickel-phosphorous, nickel and nickel-phosphorous. The coated abrasive particles, when used in fabricating a grinding wheel, greatly increases the grinding performance of the grinding wheel.

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Description

This invention relates to coated abrasives for abrasive tools or similar tools, particularly grinding wheels, in order to improve their grinding efficiency. The grinding wheels or similar tools generally are comprised of abrasive particles bonded by a resin matrix material and wherein the abrasive particles have a particular metal coating thereon to promote retention of the abrasive particles within the resin matrix. The abrasive particles include cubic boron nitride (hereinafter CBN) or diamond or similar abrasive materials used in grinding wheels or other similar tools.

It is well known in the art that a coating of nickel or titanium on CBN abrasive particles, for example, or such other abrasive particles improves their retention in the resin matrices of abrasive tools such as grinding wheels. Loss of the coated particles typically results from (a) separation of the particle from the coating and (b) separation of the coated particles from the matrix. Loss of abrasive particles which have become worn and rounded is necessary so that the abrasive tool remains sharp with the exposure of new abrasive particles, otherwise the tool will become ineffective.

Titanium coatings are typically applied to CBN abrasive particles by conventional salt bath techniques, such as is described in U.S. Pat. No. 2,746,888. An alternative procedure is described in U.S. Pat. No. 4,399,167, wherein a mixture of CBN abrasive particles and titanium powder are heat treated. Both procedures provide a thin titanium coating which is believed to be chemically bonded to the CBN abrasive.

Nickel coatings are typically applied to the CBN abrasive particles in thick layers of up to 70 weight percent of the total weight of the abrasive particle and coating by electrolytic deposition, electroless deposition and/or vapor deposition techniques. While these coated CBN abrasive particles have provided good performance in tools such as grinding wheels, the loss of the CBN abrasive particles may be considered premature. Improvements in particle retention are desired without detracting from the cutting performance of the abrasive tool.

This invention is directed to a novel coating for abrasive particles such as CBN, diamond or other similar abrasives used in abrasive tools. The preferred abrasive is CBN and this invention shall be described in terms of the CBN abrasive particles, but is applicable to the other abrasive particles such as diamond and other similar abrasive particles. Whenever CBN is mentioned, it is intended to include the other particles since CBN is employed to illustrate this invention.

Therefore, it is an object of this invention to provide coated abrasive particles.

Another object of this invention is to provide abrasive particles coated with a strongly adherent coating that aids in the retention of the abrasive particle in the grinding or abrasive tool.

Yet another object of this invention is to provide CBN abrasive particles coated with a strongly adherent coating that aids in retention of the CBN abrasive particles in a grinding wheel or other abrasive tool.

Still another object of this invention is to provide abrasive tools comprised of CBN particles having a coating thereon that aids in the abrasive particle retention in the abrasive tool and improves abrasive tool efficiency.

These and other objects will become apparent from the detailed description of this invention.

The objects of this invention are achieved by coating abrasive particles with particular coatings of metal and metal alloy compositions. The coating of this invention is comprised of particular multilayer composite metal coating compositions, as well as at least a single layer of a particular co-deposited metal coating composition. The first metal layer of the multilayer composite coating or the at least single layer co-deposited coating composition applied to the abrasive particle is in immediate contact with the surface of the abrasive particle such as, for example, CBN. This first layer in the multilayer composite coating is preferably chemically bonded to the surface of the CBN abrasive particles. This preferred chemical bonding of the first metal layer of the multilayer composite to the surface of the CBN particles enhances the retention of particles within the coating and the abrasive tool. The additional coating layers further enhance and improve the retention of the abrasive particles within the resin matrix of an abrasive tool such as a grinding wheel. As will be described subsequently, the multilayer composite coating is comprised of metal and/or metal alloy composition and the number of layers of the composite are comprised of at least three layers each of a particular metal composition.

On the other hand, the co-deposited metal composition may be at least a single layer. It has been found that this co-deposited metal layer, even as a single layer, greatly enhances the performance of an abrasive tool.

The CBN abrasive particles utilized in the practice of this invention are of a size conventionally used in grinding wheels such as, for example, those of 170/200 U.S. mesh size, but can be other mesh sizes employed in grinding wheels or other abrasive tools. Such sizes may be, for example, 80/100 to 325/400 U.S. mesh size or such other mesh sizes commonly used in abrasive tools particularly grinding wheels. The size of such abrasive particles can vary widely within the range of 1 to 1000 microns. The abrasive particles selected should be of sufficient size so that they will provide a cutting profile and not be excessively diluted by the metal coatings to be applied, which can otherwise hinder the performance of the tools made therefrom.

The CBN abrasive particles used in this invention are typically obtained by conversion of hexagonal boron nitride under high pressure and temperature, either with or without a catalyst, such as described in U.S. Pat. Nos. 4,289,503, 2,947,617, 4,188,194 and 3,212,852. Suitable forms of hexagonal boron nitride include pyrolytic boron nitride and graphitic boron nitride. Included within the term "cubic boron nitride," are nitrides having the Wurtzitic structure (WCN),

which is a compact hexagonal structure.

It is preferable to utilize CBN abrasive particles of a size directly obtained from a conversion process. However, the particles utilized in the present invention can also be obtained from larger sized materials which are milled or pulverized by conventional techniques to the size desired. The CBN abrasive particles used can also be in the form of aggregates obtained by sintering metal coated CBN fines into a large mass and pulverizing this mass to obtain aggregates of a desired size.

With respect to the multilayer composite metal coating of this invention, the first metal layer applied to the CBN abrasive particles may be one that chemically bonds to the surface of the CBN abrasive particles or may be a physical coating thereon depending on the metal composition of the first metal layer, the temperature of application and the crystal structure of the abrasive particles. If chemical bonding is desired, then the technique employed is one which allows chemical bonding of the metal to the particle surface. Chemical bonding provides an interstitial layer of metallic carbide, boride, or nitride. Therefore, the preferred metals used are those which can form a carbide, boride, oxide or nitride under conventional deposition conditions. These include titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, tungsten, and the like, and alloys thereof. Titanium is preferred in many applications when chemical bonding is desired. The term "metal," as used herein, also includes the borides, nitrides, carbides and oxides of the above metals such as, for example, titanium carbide and titanium nitride.

On the other hand, when chemical bonding is not suitable because of the inherent properties and ability of the abrasive particles to withstand the temperature of application of at least the first metal layer, the first metal layer of the multilayer composite coating is then physically adhered to the surface of the abrasive particles. For example, if the temperature of the application of the first layer in a multilayer composite coating is such that it causes deterioration or loss of crystal structure strength, then a lower application temperature for the first metal layer coating composition of this invention must be employed resulting in physical adhesion of the first metal layer instead of chemical bonding to the surface of the abrasive particles.

Also included within the scope of this invention are single layer metal compositions. These single layer metal compositions are comprised of at least a single layer of a co-deposited metal composition. While such a single layer is preferred, the co-deposited layer may be further coated with metal compositions which may comprise at least one additional layer over the co-deposited layer.

The CBN particles employed in the practice of this invention may be also comprised of crystal shapes whose idealized forms are tetrahedral, preferably truncated tetrahedra. Another form of CBN crystals may be also truncated tetrahedra with a proportion of the crystals having higher-order faces, i.e., beveled edges. Yet another form of CBN particles may be comprised of truncated tetrahedra where twinning is common leading to higher-order faces on the edges.

Also included within the scope of this invention are diamond abrasive particles. The structures of diamond and CBN crystals are similar in that they are both strongly bonded covalently with tetrahedral bonding, but are dissimilar in that diamond has a center of symmetry, whereas CBN does not. Crystals of each can be described and distinguished by a simple crystallographic system called the Morphology Index.

Also included within the scope of this invention are other abrasive particles providing they can meet the criteria of this invention. By this it is meant that the abrasive particles can be coated with the metal compositions of this invention and that they provide improved abrasive tool performance. Such other abrasive particles can include aluminum oxide, silicon carbide and other similar known abrasive particles.

The thickness and/or the amount of the first metal layer of the multilayer composite coating or the single co-deposited layer applied to the CBN abrasive particles can vary widely. It may be of submicron thickness, i.e. less than 1.0 μm such as, for example 0.5 μm . However, in the multilayer composite coating, it is preferable to have one or more of the other metal layers, i.e., other than the first metal layer, provide the bulk of the metal coating. Preferably, the thickness of the first metal layer of the multilayer composite is that obtained by conventional salt bath deposition techniques as described in U.S. Pat. No. 2,746,888. Such salt bath deposition techniques are preferred methods for depositing the first metal layer on the CBN abrasive particles. The CBN abrasive particles are typically immersed within a molten bath of one or more alkali or alkaline earth halides and a metal in a valence state higher than zero to obtain deposition of the metal. A compound containing a metal in a higher valence state can be used such as a metal chloride, or a direct current can be passed between electrodes to electrolyze the salt bath and to provide ionized metals. When depositing titanium coatings, the titanium is in divalent form either as a titanium dihalide or by passing a direct current through titanium electrodes. The temperature of the titanium salt bath is typically between 800° to 1500° F. Further details of a suitable process can be found in U.S. Pat. No. 2,746,888.

Other methods for applying the first metal layer of the multilayer composite are also suitable, including chemical vapor deposition (CVD) and more preferably by low pressure chemical vapor deposition (LPCVD) techniques. These techniques typically utilize sub-atmospheric conditions and high temperatures. Chemical vapor deposition methods are well known in the art, particularly for metal carbides, borides, nitrides and oxides, including titanium nitride and titanium carbide. Suitable chemical vapor deposition techniques, systems and devices are described in *Kirk-Othmer*

Encyclopedia of Chemical Technology, Vol. 15, pp. 262-264 (1981).

Titanium carbide LPCVD coatings are derived from titanium tetrachloride, methane gas and hydrogen gas. Titanium nitride CVD coatings are derived from nitrogen gas and titanium tetrachloride. Titanium nitride coatings can also be formed wherein the nitrogen is derived from the surface of the CBN abrasive particles.

When coating the CBN abrasive particles by CVD or LPCVD techniques, it is preferable to remove oxides and volatile impurities from the surface, particularly surface oxide contaminants such as boron oxide, by vacuum firing. A suitable technique for removing these impurities is described in greater detail within U.S. Pat. No. 4,289,503. Prior to vacuum firing, it may also be desirable to remove residual metals or organics from the surfaces of the CBN abrasive particles by a conventional acid wash.

Other methods suitable for depositing the first metal layer of the multilayer composite involves heat treating the CBN abrasive particles in the presence of powdered metal, as described in U.S. Pat. 4,399,167, or following electroless or electrolytic deposition of metals or alloys on the particles. Sufficient bonding strength must be obtained with the metal selected upon formation of an interstitial metal carbide or metal nitride layer.

The other layers can be deposited by a number of techniques which include electroless, electrolytic, and vapor deposition techniques. Electrolytic and electroless deposition techniques and systems are described in *Kirk-Othmer, Encyclopedia of Chemical Technology*, Vol. 15, pp. 241-274 (1981). Preferably, these techniques are performed under conditions which allow thick metal layers to form. Where desired, the secondary layers may be applied by LPCVD or salt bath deposition techniques.

The co-deposited metal layer composition of this invention is generally applied by the electroless deposition process and this is described in the literature as set forth above.

With respect to the multilayer composite coating, suitable metals used for the layer overcoating the first layer include nickel, cobalt, alloys thereof and the borides, nitrides, carbides, phosphides, and oxides thereof. Of the above metals, nickel and cobalt are preferred and are typically deposited by electroless coating techniques with a nickel or cobalt/hypophosphite solution at temperatures of less than about 250° F, which deposits a small percentage of phosphorus. Also suitable in the multilayer composite coating for the other metal composition layers is a co-deposited layer from a cobalt/nickel/hypophosphite solution, which also deposits a small percentage of phosphorous resulting in a co-deposited metal layer of cobalt-nickel-phosphorous. A suitable electroless deposition process is described in U.S. Pat. No. 3,556,839.

In the multilayer composite coating, the other coating layers applied to the CBN particles, after the first layer of titanium for example, are different metal layers. These subsequent metal layers are comprised of pure metal or metal-phosphorous or combinations thereof. For example, multilayer composite coated CBN particles may have a first layer comprised of titanium (chemically bonded to the CBN surface), a second layer comprised of nickel-phosphorous, a third layer comprised of pure nickel and a fourth layer comprised of nickel-phosphorous. Another multilayer composite coating on CBN particles may comprise a first layer of titanium, a second layer comprised of nickel-phosphorous, a third layer comprised of cobalt-phosphorous, and a fourth layer comprised of nickel-phosphorous. It is also within the scope of this invention that a subsequent layer of the multilayer composite may consist essentially of the co-deposition of a combination of materials such as nickel-cobalt-phosphorous. These combinations are not intended to be limiting, but are set forth for illustrative purposes.

While the above is described in terms of four layers, a three layer coating on CBN abrasive particles is also included within the scope of the multilayer composite of this invention when the first coating is other than titanium or other similar metal that chemically bonds to the surface of the CBN crystal particles. This is particularly applicable when the temperature of application of the first layer such as titanium would cause deterioration of the crystal properties such as when the first metal layer is applied above about 800° F. For example, the three layer coating composition of this invention may comprise a first layer of nickel-phosphorous or cobalt-phosphorous. The second layer may be nickel or cobalt or a co-deposited layer of nickel-cobalt-phosphorous and the third layer may be nickel-phosphorous or cobalt-phosphorous or may be a co-deposited layer of nickel-cobalt-phosphorous providing the second layer is not a co-deposited layer of nickel-cobalt-phosphorous. This is applicable when the temperature of coating of the first layer is less than about 250° F and results in the first metal layer being physically adhered to the surface of the abrasive particles instead of chemically bonded thereto.

As stated previously, the abrasive materials may be diamond, CBN or other similar abrasive materials. The coating layer in the multilayer composite, particularly the first coating layer, must be such that the crystal structure can withstand the temperature of application of the coating layer to the crystal substrate without the crystal losing structural strength. Thus, the crystal structure must withstand the temperature of application without crystal structure deterioration which, in turn, affects the grinding properties. For example, one type of CBN crystal may withstand the application of titanium as the first layer at a temperature greater than about 800° F while another type of CBN crystal may require nickel-phosphorous, for example, as the first layer due to this type of crystal structure not being able to withstand the temperature of application of titanium as the first layer. It is preferred in the practice of this invention that the CBN crystals employed are those that can withstand the temperature of application of titanium as the first layer without crystal de-

terioration. The other suitable metals that may be used in place of titanium are those recited previously as being applicable for the first metal coating on the abrasive particle substrate. Whether or not a particular crystal can withstand the temperature of application of at least the first metal layer in a multilayer composite can be determined by mere experimentation. However, it is believed that CBN abrasive particles comprised of truncated tetrahedra where twinning is common leading to higher order faces on the edges are not able to withstand the temperature of application of titanium or the other suitable metals that may be used in place of titanium as the first layer in a multilayer composite coating.

The multilayer composite metal coatings or the at least single co-deposited layer applied to CBN abrasive particles typically comprise the metal layer coatings as set forth above. The metal coating is applied in an amount equivalent to about 30-95 weight percent of the total weight of the CBN abrasive particles and coating. Preferred levels fall within the range of about 60-80 weight percent of total weight of CBN abrasive particles and coatings. The coating thickness is preferably in excess of 5 μm for CBN abrasive particles of size greater than about 35 μm . Thick coatings are desired to provide a rough textured surface for improved adhesion to the resin matrix. Amounts of metal coating larger than about 95 weight percent of the combined weight of abrasive particles and coating can provide improved retention of the abrasive particles within an abrasive tool but may dilute the abrasive excessively and reduce cutting performance. Amounts of metal coating smaller than about 30 weight percent of the combined weight can be useful for large particles where the coating thickness is greater than 5 μm , but CBN abrasive particles so coated may not show all the advantages of the present invention.

A typical embodiment is one wherein the first metal layer of the multilayer composite coating is applied by salt bath deposition and other layers are applied by an electroless deposition technique. A specific example of such a coating is one wherein the first metal layer is titanium, deposited by a salt bath technique, and the other metal layers nickel-phosphorous, cobalt-phosphorous, co-deposited cobalt-nickel-phosphorous, etc. may be deposited by electroless deposition techniques. On the other hand, a pure metal layer may be deposited by an electroplating technique.

In controlling the resulting abrasive particle retention, lubrication and heat diffusion characteristics of an abrasive tool, the thickness of the metal coating may be varied, the type of metal coatings may be varied and the size of the abrasive particles may be varied. One of ordinary skill in the art can determine the preferred metal coatings, granule sizes and coating thicknesses for the tool intended by routine investigation.

As set forth previously, one aspect of this invention is the multilayer composite coatings and compositions thereof, which may comprise at least three (3) layers or at least four (4) layers, depending upon the multilayer composite coating employed with each layer comprising a metal composition. The metal composition layers are independently selected from the metal compositions set forth herein provided that the abrasive particle substrate can withstand the application temperature of the coating layers, particularly where the first layer is chemically bonded to the surface of the abrasive particle during the deposition of the metal layer onto the abrasive particle. Preferably, the first layer is titanium depending on the crystal substrate or an alloy, carbide or nitride thereof. It is believed that in the bonding of titanium to the surface of CBN abrasive particles, for example, the interface is probably a titanium nitride. It is also preferable that the final layer or outer most layer of the multilayer composite coating comprise a metal alloy coating such as nickel-phosphorous, cobalt-phosphorous, co-deposited nickel-cobalt-phosphorous, or such other metal alloy that is within the scope of this invention.

In the application of a metal or metal alloy layer, whether it be the multilayer composite coating or the at least single co-deposited layer, the process employed may be such that more than one layer of the same metal composition may be applied wherein the layer comprising the same metal composition (metal or metal alloy) would consist of a series of layers. If the composition of the layer is of the same metal composition, i.e., pure metal or metal alloy, it shall be considered as a single layer for the purposes of this invention. For example, applying or depositing a nickel-phosphorous coating may require, depending on the process employed, the building of a series of layers of nickel-phosphorous in order to obtain the required layer thickness of nickel-phosphorous. This could involve two or more layers of nickel-phosphorous. However, for the purposes of this invention, the nickel-phosphorous layer shall be considered as a single layer even though it may consist of a series of nickel-phosphorous layers. This would also be applicable to the deposition of a pure metal layer in the event the process employed would build up a series of the pure metal layers. In such a situation, for the purposes of this invention, the pure metal layer is considered as a single layer even though it may consist of a series of pure metal layers. In the practice of this invention, each adjacent layer must be of a different metal composition.

As stated previously, the abrasive particle substrate employed must be such that it can withstand the temperature of the application of at least the first metal composition layer without losing crystal structure strength or deterioration. Thus, some CBN abrasive particles due to their crystal structure cannot withstand the application of titanium to be chemically bonded to the surface thereof. Consequently, a coating having a lower application temperature must be employed such as a nickel-phosphorous or a cobalt-phosphorous or a co-deposited nickel-cobalt-phosphorous alloy layer as at least the first metal composition layer to be applied to the abrasive particle substrate. Again, it is preferred to employ abrasive particles that can withstand the temperature of application of titanium.

After the CBN abrasive particles are coated with the coating compositions of this invention, they may be used to form an abrasive tool, such as a grinding wheel, by impregnating the coated particles within a suitable resin matrix. Impregnating the coated CBN abrasive particles within a resin matrix can be performed by conventional techniques, such as are described by Takahashi in U.S. Pat. No. 4,671,021. The coated particles are typically combined with a phenolic resin to form a mixture, which is shaped as desired within a mold. The phenolic resin is subsequently cured at elevated temperatures to bind the coated particles in a solid matrix to form a solid aggregate of high tensile strength. A preferred tool is a grinding wheel having CBN abrasive particles of a conventional size, such as, for example, 170/200 mesh size particle distribution, which are coated with the coating composition of this invention as described above and bound by a phenolic resin.

The abrasive tools provided by this invention can be of any form or shape which is conventional for tools which incorporate CBN abrasive particles. Conventional dies and molds can be utilized to form these tools. The preferred tools are grinding wheels used to grind metals. Such abrasive tools show improved wear, lubricating and heat diffusion characteristics in use as compared to grinding wheels made without CBN abrasive particles without the coating composition of this invention.

The following preferred specific embodiments are to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever.

EXAMPLE

Cubic boron nitride abrasive particles having structures described in the Tables set forth below are coated with titanium in a salt bath of titanium metal and a mixture of salts including NaCl, KCl and CaCl in the proportion 40/55/5. The temperature of the bath is between 800°-1500° F. After about 2 hours of treatment, the particles are removed and weighed to determine the amount of titanium deposited. The particles have a titanium coating of a thickness of about 0.5 to 10 μ m.

Titanium coated CBN abrasive particles based on the weight of the coated particles, were then overcoated with a series of layers of coatings as set forth in the Tables by electroless deposition processes with respect to the metal alloys. With respect to the pure metal coatings in this Example, they were applied by electroplating processes. The electroless solutions used were hypophosphite type nickel or cobalt plating formulations. The pH was usually between about 4 and about 12.0 and the temperature was maintained between 60°-95° C. Each layer was individually deposited from a separate bath and when the nickel or cobalt was exhausted, the bath was discarded and a fresh bath was used for the next layer. In the co-deposited single layer, the method of coating was electroless deposition. The weight percent of the coatings were usually about 65 to 70 percent of the combined weight of abrasive particles and coating with a phosphorus content between 2 and 11 percent thereof.

The coated CBN abrasive particles were then mixed with a conventional phenolic resin (phenol/formaldehyde resin) in a conventional weight ratio used for binding abrasives in a grinding wheel. The mixture was then molded into a grinding wheel of 7 mm width and 150 mm diameter by conventional techniques as described by Takahashi et al. U. S. Pat. No. 4,671,021.

In the Tables, the compositions recited therein have a number following the particular metal layer which number is the weight of the metal coating based on the combined weight of crystal and metal at that point with the final number being the weight percent of total metal coating based on the combined weight of abrasive particles and coating.

The relative grinding ratio (grinding efficiency) and relative power are relative to Control 1 in Table 1, and the Control in Table 2 with each Control having the relative ratio of 100.

In the Tables, the following nomenclature applies:

Ni - nickel
Ti - titanium
NiP - nickel-phosphorous
CoP - cobalt-phosphorous
Co-Ni-P - cobalt-nickel-phosphorous co-deposited

TEST OF RELATIVE GRINDING PERFORMANCE

The grinding performance of the grinding wheels produced in the Example is reported in Table 1, 2 and 3. All wheels were tested for grinding performance with a sample SKH 51 (HRC63) tool steel work piece on a reciprocating grinding table. The wheel speed was 30 m/sec. The table was reciprocated at a speed of 15 m/min and the down-feed rate was 0.025 mm. The grinding ratio (wheel loss/work-piece loss) was determined for each wheel after a predetermined period of grinding, typically more than 5 minutes. Wheels with a higher grinding ratio provided superior (lower) wear rates.

Table 1

Grinding Performance - 170/200 Mesh

Sample	Crystal Type	Coating Layers	Wet Grinding				Dry Grinding			
			G Ratio	Power	Relative G	Relative Power	G Ratio	Power	Relative G	Relative Power
Control 1	A	NiP60	469	11.8	100	100	138	5.5	100	100
Control 2	B	Ti/NiP60	706	11.6	151	98	175	4.6	127	84
1	B	Ti/NiP7/Ni25/NiP60	778	12.2	166	103	242	5.4	175	98
2	B	Ti/NiP7/CoP17/NiP60	566	11.3	121	96	211	4.7	153	85
Control 3	C	NiP60	492	12.1	100	100				
4	C	Ti/NiP7/Ni40/NiP60	906	11.7	184	97	274	5.6	199	102
5	C	Ti/NiP7/CoP17/NiP60	783	10.9	159	91	227	4.4	164	81
6	C	Ti/CoP10/NiP60	463	10.5	95	87				

A Crystal - CBN crystals comprised of truncated tetrahedra where twinning is common leading to higher order faces on the edges.

B Crystal - CBN crystals comprised of truncated tetrahedra.

C Crystal - CBN crystals comprised of truncated tetrahedra crystals with higher order faces.

Power - Watt-hour/cm²

Wet Grinding - Multi-step grinding, depth of cut 0.001 inches on M-4 steel

Dry Grinding - Multi-step grinding, depth of cut 0.0015 inches on M-4 steel

Table 2

Wet Grinding Performance - 140/170 Mesh *			
Sample	Coating Layers	G Ratio	Relative G
Control	NiP 60	430	100
1	NiP7/Ni17/NiP60	477	111
2	NiP7/Ni40/NiP60	550	128
3	Co-Ni-P Co-deposit	577	134
4	NiP7/CoP17/NiP60	587	137

* Crystals - CBN crystal A as described in Table 1.

Wet Grinding - Multi-step grinding on M-4 steel depth of cut 0.001 inches

Table 3

Plunge Grinding Performance (M-2 Steel) Wet Grinding				
Sample	Mesh Size CBN Crystal C	Coating Layers	Depth of Cut Inches	G Ratio
Control	170/200	NiP60	0.0015	89
1	170/200	Ti/NiP7/CoP17/NiP60	0.0015	335
2	140/170	Ti/NiP6/Co-Ni-P60	0.0015	326
3	140/170	CTi/NiP6/Co-Ni-P60 co-deposit	0.0015	353

CTi - Titanium was deposited on the CBN by Vapor Deposition techniques.

Crystal - CBN Crystal C as described in Table 1.

co-deposit - cobalt to nickel ratio of 1 to 1 on a weight basis.

As seen from Tables 1, 2 and 3, the abrasive compositions of the invention having the multilayer composite coating or the single co-deposited nickel-cobalt-phosphorous metal layer have significant improvement in grinding efficiency as shown by the G Ratio, Relative G and Relative power in Table 1 where the multilayer composite is a four (4) layer coating with titanium as the first metal layer chemically bonded to the CBN surface. In Table 2, the multilayer composite coating consisting of three (3) layers where the first metal layer is physically adhered to the surface of the CBN particles (Sample 1, 2 and 4) showed significant improvement in grinding efficiency. Please note G Ratio and Relative G. Also as shown in Table 2, the single co-deposited metal coating (Sample 3) also demonstrated significant improved grinding efficiency. In Table 3, Plunge Grinding Performance was dramatically better with the multilayer composite coatings shown therein. Plunge grinding is a severe grinding test and the improvement was almost four fold over the control.

Claims

1. An abrasive composition suitable for use in abrasive tools comprised of abrasive particles having a coating thereon selected from the group consisting essentially of (a) a multilayer composite coating comprised of at least four metal layers wherein the first metal layer is chemically bonded to the surface of the abrasive particles and is selected from the group consisting essentially of titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, tungsten, and alloys thereof and wherein the subsequent metal layers are selected from the group consisting essentially of nickel, cobalt, alloys thereof, the borides, nitrides, phosphides and oxides thereof and co-deposited metal compositions thereof with the last outer layer being a metal alloy having a metal composition other than the immediate preceding layer; (b) a multilayer composite coating comprised of at least three layers wherein the first layer is physically adhered to the surface of the abrasive particles and is selected from the group consisting essentially of nickel-phosphorous and cobalt-phosphorous and wherein the subsequent metal layers are selected from the group consisting of nickel, cobalt, nickel-phosphorous, cobalt-phosphorous, and co-deposited nickel-cobalt-phosphorous with the last outer layer being a metal alloy having a composition other than the immediate preceding layer; and (c) at least a single metal layer coating of a co-deposited metal composition of nickel-cobalt-

phosphorous, which metal coating is physically adhered to the surface of the abrasive particles.

2. The abrasive composition of claim 1 coated with a multilayer composite metal coating wherein the first metal is titanium chemically bonded to the surface of the abrasive particles.
3. The abrasive composition of claim 1 wherein the abrasive particles are cubic boron nitride or diamond.
4. The abrasive composition of claim 1 wherein the last outer layer of the multilayer composite is nickel-phosphorous.
5. The abrasive composition of claim 3 wherein the multilayer composite is comprised of four metal layers consisting essentially of (1) titanium chemically bonded to the surface of the abrasive particles, (2) the next adjacent layer being nickel-phosphorous, (3) the layer adjacent to (2) being nickel, and (4) the last outer layer being nickel-phosphorous.
6. The abrasive composition of claim 3 wherein the multilayer composite is comprised of four metal layers consisting essentially of (1) titanium chemically bonded to the surface of the abrasive particles, (2) the next adjacent layer being nickel-phosphorous, (3) the layer adjacent to (2) being cobalt, and (4) the last outer layer being nickel-phosphorous.
7. The abrasive composition of claim 3 wherein the multilayer composite is comprised of four layers consisting essentially of (1) titanium chemically bonded to the surface of the abrasive particles, (2) the next adjacent layer being nickel-phosphorous, (3) the next adjacent layer to (2) being cobalt-phosphorous, and (4) the last outer layer being nickel-phosphorous.
8. The abrasive composition of claim 3 wherein the multilayer composite is comprised of four layers consisting essentially of (1) titanium chemically bonded to the surface of the abrasive particles, (2) the next adjacent layer being nickel-phosphorous, (3) the next adjacent layer to (2) being cobalt, and (4) the last outer layer being nickel-phosphorous.
9. The abrasive composition of claim 1 wherein the multilayer composite is comprised of three layers consisting essentially of (1) nickel-phosphorous physically bonded to the surface of the abrasive particles, (2) the next adjacent layer being nickel and (3) the last outer layer being nickel-phosphorous.
10. The abrasive composition of claim 1 wherein the multilayer composite is comprised of three layers consisting essentially of (1) nickel-phosphorous physically bonded to the surface of the abrasive particles, (2) the next adjacent layer being cobalt and (3) the last outer layer being nickel-phosphorous.



European Patent
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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			C09K B24D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 7 May 1997	Examiner Nicolas, H
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons</p> <p>& : member of the same patent family, corresponding document</p>			

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